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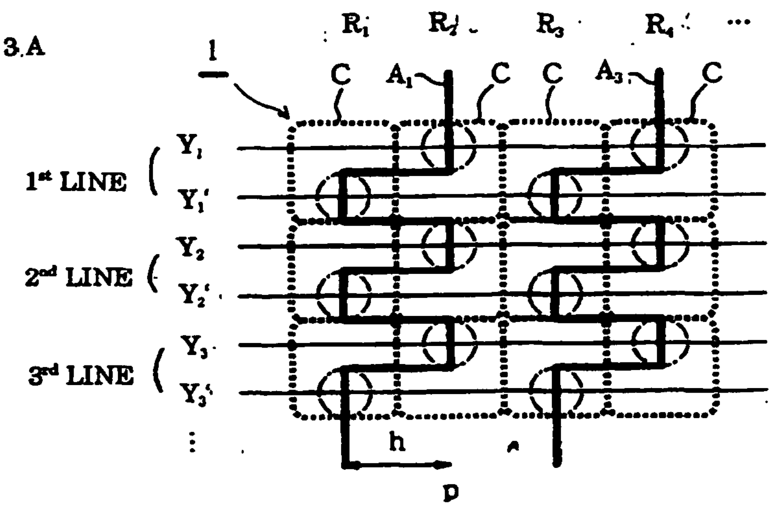
(54) A display panel and its driving method

(57) A single row of data electrodes (A) orthogonal to scan electrodes (Yi,Yi') is arranged so as to be involved to adjacent two rows, where either one side of the data electrode (A) can be addressed by the use of two scan electrodes for a single line, so that the quantity of the data electrodes (A) be reduced to a half resulting in a reduction of reactive power required to charge the capacitance between the adjacent data electrodes.

Fig. 3.A



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Description

[0001] This invention relates to a matrix type display panel, such as a plasma display panel (PDP), plasma addressed liquid crystal display, (PALC) or liquid crystal display (LCD), and driving methods for such display panels.

[0002] Display panels have been getting popular as a display means to replace cathode ray tubes (CRTs). PDPs in particular have been employed as public displays such as information boards at railway stations and airport terminals due to their advantageous features of wide viewing angles and suitability for large display screens. Moreover, PDPs have become widely accepted in home use, such as television receivers and computer monitors, upon the practical success of the color screen.

[0003] In the matrix type display panel, a line sequential addressing operation, that is a setting operation of the contents to be displayed, was performed by the use of scan electrodes to designate cells, that is display elements, on each line and data electrodes to designate cells on each row.

[0004] A single scan electrode was arranged for each line, and a single data electrode was arranged for each row orthogonal to the lines in the prior art simple matrix type display panel. That is, in a screen having m rows and n lines as shown in Fig. 14, m data electrodes D1, D2 ...Dm and n scan electrodes S1, S2...Sn were provided. The arrangement pitch of scan electrodes S1, S2...Sn was equal to the cell pitch along the row direction; and the arrangement pitch of data electrodes D1, D2 ...Dm was equal to the cell pitch along the line direction. In PDPs of three-electrode surface discharge type, a structure now commercially available as a color display device, two electrodes are arranged for each line; however, this structure to define the individual cells can be considered as a simple matrix structure similar to that shown in Fig. 14 because only one of the two electrodes is used for selecting the line.

[0005] In the prior art structures, there have been problems in that static capacitance between the electrodes becomes large. Particularly in the color display panel including the cells of primary colors, R, G & B, aligning along the line direction, the influence of static capacitance between the data electrodes was- serious because the row pitch is approximately one third of the line pitch. Cell size reduction to provide a high resolution display causes an increase in the capacitance, resulting in an increase in reactive power consumed in charging the capacitance. Waveforms of the driving pulses become less steep resulting in a considerable delay of the display response.

[0006] It is a consideration of the invention to provide display panels and driving methods in which reactive power in the driving circuit is reduced by reducing electrostatic capacitance between the data electrodes.

[0007] In the present invention, two adjacent rows are grouped by a single data electrode an arrangement pitch of which is substantially twice the cell pitch along the line direction. The shape and dimension of the data electrodes are chosen such that a single data electrode is related to both the adjacent rows. In order to enable selection of an individual cell on a single one of the grouped rows by designating the one of two rows, two or more scan electrodes are arranged for a single line. The shape of the data electrode is such as to effectively confront the scan electrodes at each cell of the related two rows.

[0008] Compared with the prior art structure in which a single data electrode is provided for each row, the space d between the adjacent two data electrodes is a value p-w, where the cell pitch p is reduced from the electrode width w; in the present invention, the data electrode space d is a value reducing the electrode width w from the double of the cell pitch 2p, that is 2p-w.

[0009] When displaying, a period allocated for a single line in a line sequential addressing period is divided so that the first and the second rows of each data electrode are set by time-sharing. Then, the number of the scans becomes twice that of the prior art method: however, when the screen is divided into two along the row direction it is possible to avoid the increase in the time required for the addressing of the whole screen by performing the addressing operation in parallel for the divided screens.

[0010] Reference will now he made, by way of example, to the accompanying drawings wherein like numerals refer to like parts throughout, and in which:-

Fig. 1 is a perspective view schematically illustrating an internal structure of a first PDP of a first preferred embodiment of the present invention;
Fig. 2 is a plan view schematically illustrating an electrode structure of the first PDP;
Fig. 3A and Fig. 3B schematically illustrate a matrix of electrode structure of the first PDP;
Fig. 4 is a plan view schematically illustrating an electrode structure of a second PDP;
Fig. 5 is a matrix schematically illustrating an electrode structure of the second PDP;
Fig. 6 is a plan view schematically illustrating an electrode structure of a third PDP;
Fig. 7 is a plan view schematically illustrating an electrode structure of a fourth PDP;
Fig. 8 is a plan view schematically illustrating an electrode structure of a fifth PDP;
Fig. 9A is a cross-sectional view cut along the line direction schematically illustrating the fifth PDP;
Fig. 9B is a cross-sectional view cut along the row direction schematically illustrating the fifth PDP;
Fig. 10 is a plan view schematically illustrating electrode structure of a sixth PDP;

Fig. 11 is a perspective view schematically illustrating a structure of separator walls of the sixth PDP;
Fig. 12 is a plan view schematically illustrating an electrode structure of a seventh PDP;
Fig. 13 is a plan view schematically illustrating an electrode structure of a eighth PDP;
Fig. 14 is a matrix schematically illustrating an electrode structure of a prior art PDP;
Fig. 15 schematically illustrates driving waveforms employed in addressing period of TABLE 2; and
Fig. 16 schematically illustrates driving waveforms of a ninth preferred embodiment.

[0011] By way of background information,a surface discharge type PDP, to which the present invention is typically applied, will first be explained.

[0012] A surface discharge type PDP is normally such that a pair of sustain electrodes alternately becoming anode and cathode are arranged in parallel on an inner surface of one of substrate pair for an AC drive, i.e. an alternating current drive, in order to sustain a lighting state utilizing wall charges. In this type, a long life in the operation can be expected by reducing the deterioration of a fluorescent material layer caused by ion bombardment of the discharge owing to the arrangement of the fluorescent material layer for the color display on a second substrate opposite a the first substrate carrying the sustain electrode pairs. In illustrating the hereinafter-described PDPs, the same numerals are denoted to the corresponding structural elements regardless of any difference in the detailed shape.

[0013] Fig. 1 schematically illustrates an internal structure of a first PDP 1 of a first preferred embodiment of the present invention.

[0014] PDP 1 is an AC type color PDP formed of paired substrates 10 & 20 where the basic structure is similar to the prior art three-electrode type surface discharge structure; except that three horizontal electrodes Yi, Xi & Yi', referred to hereinafter respectively as Yi, Xi, Yi' electrodes, extending along a line direction, i.e. along the horizontal direction in the drawing, and an address electrode A, which was called a data electrode, extending along the row direction, i.e. along the vertical direction in the drawing, are crossed with each other. The Yi electrode plays both a role of a sustain electrode for causing a surface discharge and a role of a first scan electrode in the addressing operation; the Xi electrode plays a role as a sustain electrode only; and the Yi' electrode plays a role as a sustain electrode and a role as a second scan electrode in the addressing operation as described later in detail. Each of the Yi, Xi & Yi' electrodes is formed of a transparent electrically conductive film 41 and a metal film 42 stacked thereon, and is arranged on an inner surface of front glass substrate 11.

[0015] An approximately 30 μm thick dielectric material layer 17 extends all over the display area so as to cover the Yi, Xi & Yi' electrodes. Upon a surface of dielectric material layer 17 is coated a protecting layer 18 formed of magnesium oxide (MgO). A data electrode acts as an address electrode for causing wall charges in the cell during the address period. Accordingly, the data electrodes will be referred to hereinafter as address electrodes A. Address electrodes A are arranged on an inner surface of back glass substrate 21. Upon dielectric material layer 24 covering address electrddes A are arranged separator walls 29, typically 100μm high, 30μm wide, equally spaced out the shape of stripes in a plan view. A discharge space 30 is divided thereby into individual cells on each line along the line direction.

[0016] Three fluorescent material layers 28R, 28G & 28B are provided respectively to emit primary colors R (red), G (green) & B (blue) of the color display so as to cover the back substrate's inner surface including dielectric layer 24 on an upper part of address electrodes A and sides of separator walls 29. A single pixel of the display is constituted with three sub-pixels formed in each discharge space 30 and aligned along the line direction. Emitted colors of sub-pixels aligned along the row direction, that is in the valley between the two adjacent separator walls, are identical. Due to separator walls 29 having the stripe pattern in the plan view, the portion which corresponds to each row in the discharge space 30 continuously crosses over all the lines.

[0017] Fig. 2 is a plan view schematically illustrating an electrode structure of first PDP 1. Figs. 3 schematically illustrate an electrode matrix of first PDP 1. In Figs. 3 the X electrodes are omitted for simplicity of description. A chain circle indicates a lighting center of each cell C.

[0018] First PDP 1 has two features related to the present invention as shown in Fig. 2. A first feature is that a single address electrode A is provided for two adjacent rows instead of a single row, such that the address electrode A is patterned in a shape of a regularly zig-zagging stripe so as to relate to the two adjacent rows. Another feature is that the Yi & Yi' electrodes in pair are arranged on both sides of each Xi electrode so that both of the X electrodes can respectively relate to the Xi electrode placed at the middle.

[0019] The Xi electrodes are in a particular stripe shape arranged such that in an even numbered row, for example 28-2, each Xi electrode has a portion Xexi expanding toward Yi electrodes and in an odd numbered row, for example 28-1, a portion Xexi' alternately expanding toward Yi' electrodes. So as to meet thus expanding portions Xexi and Xexi' of the Xi electrode, Yi & Yi' electrodes are respectively patterned such that a portion, of the electrodes, Yexi & Yexi' confronting the expanding portions Xexi and Xexi' of the Xi electrode respectively expands toward the expanding portion Xexi and Xexi' of the Xi electrode alternately for every two rows. In other words, the width of each Yi & Yi' electrode is locally and periodically expanded so as to confront (be adjacent to) the expanded portions Xexi or Xexi' of Xi electrode. Gaps between the confronting expanding-portions are the surface discharge gap, typically of 50 μm.

[0020] Each address electrode A is patterned to turn in a zigzag in a plan view such that after crossing over the discharge gap between the Yi electrode and the Xi electrode located in an even numbered discharge space 28-2 the address electrode horizontally turns toward the adjacent odd numbered discharge space 28-1 and then turns to cross over another discharge gap between the Yi' electrode and the Xi electrode, and after crossing over the discharge gap between the Yi' electrode and the Xi electrode the address electrode turns to go back to the adjacent original even numbered discharge space 28-2. As described above, the practical Yi, Xi and Yi' electrodes are respectively formed of a stack of a typically 100 μm transparent electrically conductive film for enhancing the effective electrode area while avoiding shielding of the light and a metal film for supplementing the electrical conductivity. Thus shaped patterns of transparent electrically conductive films are shown in Fig. 2. The pattern of metal films of the Yi , Xi and Yi' electrode is a typically 50 μm wide straight stripe except at the expanded portions therof. The X electrodes are also formed of a stack of a typically 100 μm transparent electrically conductive film and a typically 50 μm wide metal stripe thereon.

[0021] The arrangement pitch ph (typically 260 μm) of address electrodes A is twice the typically 130 μm cell pitch h along the line direction as shown in Figs. 2 and 3. Accordingly, the address electrode arrangement clearance is approximately twice that of the prior art structure, so that the reactive power spent in the electrostatic capacitance between the adjacent address electrodes can be reduced down to approximately half. In watching the two adjacent rows which relate to the address electrode therebetween, the location of lighting center of each cell C is deviated along the row direction as shown in Fig. 3B. Accordingly, if the lighting center is considered to be at the center of the cell C each line is in a zigzag having the cells deviated vertically by half a pitch pv from an odd-numbered line to an adjacent even-numbered line also as shown in Fig. 3B. In this case as well, it is needless to say that the Yi & Yi' electrodes are arranged to relate to a single line quite similarly to Fig. 3A. In this specification, a single line is a group of as many as m cells C in total having the same sequential number in the screen formed of m x n cells.

[0022] In performing the displaying of the first PDP 1, the line-sequential addressing operation is first performed utilizing twice the address electrode A for each line. In other words, the addressing period, i.e. a scan period, for a single line is divided into a first half and a second half. During the first half, the Yi electrode is activated, i.e. selected to scan, and at the same time a selected address electrodes is activated in accordance with the contents to be displayed. In practice, a pulse of a predetermined peak voltage value is applied to this so that an opposing discharge, which is a discharge in the opposing direction of the substrates, is generated between the thus selected Yi electrode and thus selected first address electrode Al at a cell on an even-numbered row as denoted with 28-2 in Fig. 2.

[0023] The thus-generated opposing discharge triggers a surface discharge along the gap between the expanding portion Yexi & Xexi respectively of Xi electrode and the Yi electrode. Status of wall charges in each cell on the selected line and row are thus set by the sequence of address discharges caused by the address electrode.

[0024] If the addressing operation is of an erasing type, the wall charges are erased by an addressing discharge prior to the addressing operation from the cells C selected from the charged cells on the entire screen. If a write-address type, the wall charges are formed by an address discharge only in the cells selected from non-charged cells on the entire screen.

[0025] Subsequently in the second half the Yi' electrode is activated, and concurrently thereto are activated the cells in odd-numbered rows 28-1 and 28-3 ... by addressing the address electrodes A1, A3 ... selected in accordance with the contents to be displayed, so that the cells in the odd-numbered rows are addressed in the same way as in the first half of the period.

[0026] The above-described two-step addressing operation is performed sequentially on each line so as to set the charged states on the entire screen. The operations of the electrodes during the addressing operation are shown in TABLE 1, where "ON" indicates the related electrode is active to be selected.

TABLE 1

Scan Period	Yj and Yj' Electrodes 1st: Y1	Y1'	2nd: Y2	Y2'	...	ith lines: Yi	Yi'	Data of Address/Data Electrode A_1, A_3 ... A_{m-1}
1st half of 1st line	ON	--	--	--	--	--	--	data of even-numbered row
2nd half of 1st line	--	ON	--	--	--	--	--	data of odd-numbered row
1st half of 2nd line	--	--	ON	--	--	--	--	data of even-numbered row
2nd half of 2nd line	--	--	--	ON	--	--	--	data of odd-numbered row
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
1st half of ith line	--	--	--	--		ON	--	data of even-numbered row
2nd half of ith line	--	--	--	--		--	ON	data of odd-numbered row

[0027] On completion of the addressing operation, sustain pulses of a predetermined peak voltage are applied alternately to electrodes, where the sustain pulses are commonly applied to Y & Y' electrodes respectively without being distinguished. Accordingly, surface discharges take place on the application of the sustain pulses in the cells in which the correct amount of wall charges are existing at the completion of the addressing operation so as to sustain the lighting state owing to the wall charges cyclically generated therein.

[0028] During the surface discharges the fluorescent material layers 28R, 28G and 28B shown in Fig. 1 are locally excited by an ultra-violet light radiated from the discharge gas, and emit light of respective colors. Only the visible light that can penetrate the front glass substrate 11 contributes to the display.

[0029] A second preferred embodiment of the present invention is hereinafter described with reference to Fig. 4 illustrating a plan view of a second PDP 2, and Fig. 5 illustrating an electrode matrix of second PDP 2.

[0030] Second PDP 2 is another surface discharge type panel of the reflection type, where the fluorescent material layers are placed on the back substrate similar to first PDP 1 shown in Fig. 1. It is similar to first PDP 1 as well in that address electrodes A are patterned regularly in zigzag stripes relating to two adjacent rows.

[0031] The structural difference of PDP 2 from PDP 1 is that horizontal electrodes extending in the line direction are arranged repeatedly in the order of Xi, Yi, Xi+1, Yi+1 ... by an equal clearance without idle space between Yi' and Yi+1 electrodes.

[0032] The Yi electrodes of each line play both the role of a scan electrode in the addressing operation and the role of a sustain electrode for causing a surface discharge in the sustain period. Xi and Xi+1...electrodes play both the role of a supplemental scan electrode for the scan electrode Yi in the addressing operation and the role of a sustain electrode for causing a surface discharge in the sustain period as described later in detail. Accordingly, in order to name these horizontal electrodes simply, these electrodes will be referred to in the second and the subsequent preferred embodiments as an Xi electrode and Yi electrode, respectively, where the numeral i indicates an odd number. The quantity of each electrode is the quantity of the lines n in the screen. Each Yi electrode is patterned such that the width of the stripe expands cyclically and alternately from a side thereof and from another -side for each line as denoted with Yexi and Yexi+1, where the suffix exi indicates expansion toward Xi electrode, and the suffix exi+1 indicates expansion toward Xi+1 electrode. In order to conform to the expanded portions Yexi and Yexi+1 of the Yi electrode, Xi & Xi+1 electrodes are patterned such that a portion, of Xi & Xi+1 electrodes, confronting the expanded portions Yexi or Yexi+1 of the Yi electrode respectively expands toward the expanded portion Yexi and Yexi+1 of the Yi electrode alternately for every two rows. Each address electrode A is patterned in a zigzag to sequentially cross over surface discharge gaps between the expanded portions confronting each other of Xi, Yi & Xi+1 electrodes in a similar way to the first preferred embodiment.

[0033] As seen in Fig. 5, each Yi electrode corresponds to an i-th line of the screen as an individual electrode, to

which an independent potential can be applied. Each of Xi & Xi+1 electrodes located respectively at both the sides of Yi electrode respectively relates to two lines adjacent to the X electrode. The first one X1 of the plural X electrode arrangement relates to the top line only. The last one opposite from the above-mentioned first X electrode X1 relates to the last n-th line only. Odd-numbered X electrodes X1, X3 ... counted without distinguishing which side of Y electrode the X electrode is confronting are electrically common; and even-numbered X electrodes X2, X4 ... are electrically common as well.

[0034] The Y electrodes play the role of scan electrodes plus the role of sustain electrodes; and the X electrodes play the role of supplemental scan electrodes plus the role of sustain electrodes.

[0035] The arrangement pitch p of address electrodes A of the second PDP 2 is twice the pitch of the prior art. Accordingly, the arrangement pitch of the address electrodes becomes almost twice the cell pitch along the line direction whereby the reactive power consumed for the static capacitance can be reduced by almost half.

[0036] In driving PDP 2, like PDP 1, the addressing period of a single line is divided into first and second half periods. In the first half period, the common odd-numbered X electrodes Xi, where the numeral i is now an odd number, and the i-th Y electrode Yi of the i-th line to be selected, i.e. to be scanned, are activated; and concurrently thereto address electrodes A_1, A_2 ...$A_{(M/2)}$ selected in accordance with the contents to be displayed are activated. The quantity of address electrodes is m/2, that is a half of the number m of the rows. Thereby, an address discharge takes place in the cells on the rows which relate to thus activated address electrodes among the even-numbered rows 28-2, 28-4 ... so that a predetermined charged state is established in the thus-selected cells. In the second half period, the common even-numbered X electrodes Xi+1 and the same i-th Y electrode Yi of the i-th line are activated; and concurrently thereto the address electrodes selected in accordance with the contents to be displayed are activated. Thereby, the address discharge takes place in the cells on the row which relates to the thus-activated address electrode among the odd-numbered rows 28-1, 28-3 ...so that a predetermined charged state is established in thus selected cells.

[0037] Such a two-step addressing is performed sequentially for each line-so as to establish the charged state distribution on the entire screen. Driving of the electrodes during the addressing operation is shown in TABLE 2, where "ON" indicates the related electrode is active. Waveforms of the driving voltages are illustrated in Fig. 15, which will be explained later in detail.

TABLE 2 i: an odd number

Scan Period	1^{st} 2^{nd} ... i^{th} lines Y_1	Y_2	Yi	Xi	Xi+1	Data of Address/Data Electrodes A_1 ... $A_{(m/2)}$
1^{st} half of 1^{st} line	ON	--	--	ON	--	data of even-numb'd row
2^{nd} half of 1^{st} line	ON	--	--	--	ON	data of odd-numb'd row
1^{st} half of 2^{nd} line	--	ON	--	ON	--	data of even-numb'd row
2^{nd} half of 2^{nd} line	--	ON	--	--	ON	data of odd-numb'd row
⋮	⋮	⋮	⋮	⋮	⋮	⋮
1^{st} half of i^{th} line	--	--	ON	ON	--	data of even-numb'd row
2^{nd} half of i^{th} line	--	--	ON	--	ON	data of odd-numb'd row

[0038] On completion of the addressing period, sustain pulses of a predetermined voltage value are applied to all the X electrodes Xi & Xi+1 without being distinguished, and alternately to all the Y electrodes, as shown in Fig. 5. Thereby, the surface discharges take place every time the sustain pulses are applied so as to sustain the lighting state in the cells holding the correct amount of the wall charges at the completion of the addressing operation.

[0039] A third preferred embodiment of the present invention is hereinafter described with reference to Fig. 6 illus-

trating a plan view of an electrode structure of a third PDP 3.

[0040] Third PDP 3 is a reflection type PDP as well, similar to the above-described first and second PDPs 1 and 2. Particularly, the electrode structure of front substrate is identical to that of second PDP 2 shown in Fig. 4, in which there are provided three kinds of horizontal electrodes Xi, Yi and Xi+1 arranged equally spaced out.

[0041] A feature of third PDP 3 is that the address electrode A is shaped not as a zigzag but as a wide straight stripe symmetrically relating to the adjacent two rows. Arrangement pitch p of address electrodes A is twice the cell pitch h, and the width w of address electrode A is typically 130 μm, adequately larger than typically the 30μm wide separate wall 29. In the PDP 3, owing to the straight configuration of the address electrodes it is easy to align the rows during assembly of the front substrate and the back substrate. However, the wider address electrode for the easier address discharge reduces the arrangement gap between the adjacent address electrodes resulting in less effect for reducing the capacitance.

[0042] The addressing operation in displaying third PDP 3 is identical to that of second PDP 2 described above. That is, the contents to be displayed are set sequentially line by line by doubling the use of address electrode for a single line as shown in TABLE 2.

[0043] A fourth preferred embodiment of the present invention is hereinafter described with reference to Fig. 7 illustrating a plan view of an electrode structure of a fourth PDP 4.

[0044] The structure of fourth PDP 4 is basically identical to those of the second and third PDPs 2 and 3 except the address electrode configuration. Address electrode A of fourth PDP 4 is formed of a particular stripe having a straight base extending straight from one end of the row to the other end and expanding portions, i.e. pads, Apad expanding alternately from a side and the other side of the base toward the line directions so as to regularly vary the width of the stripe. The width of the straight base is typically 50 μm, which is narrower than one 130μm of the third PDP 3. The expanding portions are provided so as to confront each discharge gap in accordance with the pad arrangement of the Xi, Yi and Xi+1 electrodes. The width of the expanding portion Apad is typically 90 μm measured from the opposite straight side. Such a pattern of address electrodes A enhances the possibility of address discharges while allowing the widest clearances, typically 160 μm, between the adjacent address electrodes. Moreover, the total lengths of each address electrode A are shorter than those of the address electrodes in the zig-zag of first and second PDPs 1 and 2 so as to lessen the power consumption generated by the electrical resistance of the address electrodes. The addressing operation in displaying fourth PDP 4 is identical to those of second and third PDPs 2 and 3 described above.

[0045] A fifth preferred embodiment of the present invention is hereinafter described with reference to Fig. 8 illustrating a plan view of an electrode structure of the fifth PDP 5, and Fig. 9A and Fig. 9B illustrating sectional views of a main portion of fifth PDP 5.

[0046] Fifth PDP 5 is a reflection type PDP similar to the above-described second, third and fourth PDPs 2, 3 and 4. Particularly, the structure of the address electrodes is identical to that of fourth PDP 4 shown in Fig. 7.

[0047] A structural feature of fifth PDP 5 is that the Yi, Xi, Yi' electrodes are patterned in straight stripes of respectively constant width and that there are provided second separator walls 19 to partially connect the adjacent separator walls 29 so as to prevent unnecessary discharge coupling along the row direction. Each of Yi, Xi, Yi' electrodes is formed of a stack of a wide, i.e. typically 150 μm, transparent electrically conductive electrode 41 and a narrow, i.e. typically 50 μm wide, metal film 42 stacked thereon at the center of the width of transparent electrically conductive electrode 41 as shown in Figs. 9. The straight Yi, Xi, Yi' electrodes are advantageous for better yield in production than the Yi, Xi, Yi' electrodes having alternate pads as in fourth preferred embodiment because the patterning accuracy is not so critical as in the fourth preferred embodiment, and are advantageous also in enhancing the brightness owing to the wide electrode width.

[0048] However, the equally spaced clearance between the Yi, Xi, Yi' electrodes may cause an undesirable discharge there between. Accordingly, in order to prevent the undesirable discharge caused from the equally spaced clearance between the Yi, Xi, Yi' electrodes there are provided in fifth PDP 5 second separator walls 19 for dividing the discharge space 28' to each line on insulating layer 17 on the inner surface of front substrate 11. Similarly to the previous preferred embodiments the cell positions in the odd-numbered row and the even-numbered row are shifted along the row direction. Accordingly, the location of second separator wall 19 is shifted by a half pitch in the adjacent row. The height of second separator 19 is lower than that of first separator wall 29 so that the gas in the discharge space can be exhausted and refilled therein after the substrates are assembled together, and moreover, so that a priming effect can be kept between the cells in the row. If the substrates are to be assembled in vacuum or in an atmosphere of a discharge gas, the second separator wall 19 can be high enough to completely partition the discharge space 28' into each cell.

[0049] Instead of providing second separator wall 19 there may be provided a dielectric layer having a higher dielectric constant than that of insulating layer 17 buried therein, or having a lower secondary-emission constant, or a barrier electrode.

[0050] The ad-dressing operation in driving the fifth PDP 5 is identical to those of second to fourth PDPs 2 to 4 described above.

[0051] A sixth preferred embodiment of the present invention is hereinafter described with reference to Fig. 10 illus-

trating a plan view of an electrode structure of a sixth PDP 6, and Fig. 11 illustrating a sectional view of separator wall structure of sixth PDP 6.

[0052] Sixth PDP 6 is a reflection type PDP as before, with an electrode structure basically similar to fifth PDP 5 shown in Fig. 8 except that the plan view of address electrodes is narrower than that of the fifth preferred embodiment and the plan view of the shape of separator wall is different as described later. Address electrode A of sixth PDP 6 again is in a stripe shape the width of which varies between the straight base portion and the expanded portions.

[0053] The most important feature of sixth PDP 6 is that discharge space 30 is divided with zigzagging stripes of separator walls 29'. That is, each separator wall 29' is arranged in zigzag of a predetermined pitch and in an amplitude in the plan view so that a clearance between the adjacent separator wall 29' becomes smaller than a predetermined value cyclically along the row direction. The predetermined value is such a dimension as to inhibit the discharge, and is determined by discharge condition such as the gas pressure. Separator walls are separated along the line direction from the adjacent separator wall; accordingly, the space between each separator wall 29, that is, the row space, is continuous to cross-over all the lines. Accordingly, the uniformly-aligning process of fluorescent material layers 2 8 R, 2 8 G and 2 8 B and exhausting (evacuating) after assembly are easier than those of the fifth PDP 5 where the internal space is divided along both the row direction and line direction. The electrode dimensions are substantially same as those of Fig. 4.

[0054] Providing that the numeral i indicates an odd number, the expanded portion Aexo confronting the surface discharge gap gi between Xi electrode and Yi electrode is located on the odd-numbered row R1, R3 ..., that is on the left hand side of the address electrode in the figure. The expanded portion Aexe confronting the surface discharge gap gi' between Yi electrode and Yi+1 electrode is located on the even-numbered row R2, R4,... This relationship is drawn in Fig. 8 in a fashion reversed from that of the fifth PDP 5. Such a difference in the shape of the address electrodes does not affect on the driving characteristics. However, in activating the Xi electrode, e.g. X1, together with Y electrode having the same suffix number, e.g. Y1, during the first half of the address period the address electrode must be activated with the data of the odd-numbered row; while in activating the even numbered electrode Xn+1, together with Y electrode having the same suffix number, e.g. Y2, the address electrode must be activated with the data of the even-numbered row.

[0055] The surface discharge does not take place at the discharge space having the small width 50 μm in the line direction. The surface discharge takes place in the discharge space having the wide width 150 μm between the separator walls adjacent along the line direction, and between confronting Yi electrode and Xi+1 electrode so as to form a single cell. Accordingly, the cells are aligned in zigzag along both the row direction and the line direction. In sixth PDP 6, the three diagonally adjacent cells respectively of R, G and B constitute a single pixel. In other words, the arrangement form of the three colors for the color display is of a triangle form, or a delta form arrangement. The expanded portions Aexo and Aexe of address electrodes are arranged so as to respectively confront the surface discharge gaps.

[0056] At the Xi, Yi electrodes, both the sides thereof toward the row direction are involved in the surface discharges except the sustain electrode at the arrangement ends. Accordingly, a metal film, i.e. a 50 μm wide bus conductor, is stacked along the center of the width 150 μm of a transparent electrically conductive film 41 similar'to that of fifth PDP 5. The zigzag configuration of separator walls 29' allows an enhancement of brightness owing to the wider discharge space of each cell C compared to the case where the separator walls are simply straight.

[0057] The driving of each electrode during the addressing period in operation of sixth PDP 6 is shown in TABLE 3, which is basically identical to those of TABLE 2; however, the combination of the voltage applications to the Xi, Yi, Xi+1 electrodes and the row data to be applied to the address electrode A is different from that of TABLE 2. In the table, "ON" indicates to activate the related electrode.

TABLE 3 i: an odd number

Scan Period	1^{st} Y_1	2^{nd} Y_2	... i^{th} Yi	lines Xi	Xi+1	A_1, A3 .... A(m/2)
1^{st} half of 1^{st} line 2^{nd} half of 1^{st} line	ON ON	-- --	-- --	ON --	-- ON	data of even-numb'd row data of odd-numb'd row
1^{st} half of 2^{nd} line 2^{nd} half of 2^{nd} line	-- --	ON ON	-- --	ON --	-- ON	data of even-numb' row data of odd-numb'd row
---- ⋮ ----	--- ⋮ ---	--- ⋮ ---	--- ⋮ ---	--- ⋮ ---	--- ⋮ ---	------ ⋮ ------
1^{st} half of i^{th} line 2^{nd} half of i^{th} line	--- ---	--- ---	ON ON	ON --	-- ON	data of even-numb'd

Fig. 12 schematically illustrates an address electrode structure of a seventh PDP 7, where the address electrode configuration is basically identical to those of the fourth to sixth preferred embodiments PDPs 4 to 6 in that the expanded portions are cyclically and alternately extended from the sides. The entire screen of seventh PDP 7 is divided into two divided screens ES1 & ES2 in the row direction. In each of the divided screens ES1 & ES2, address electrodes A are arranged along the line direction spaced by p, twice the cell pitch h. Address electrodes Aa in the upper divided screen ES1 are driven by a first address driver 89A; and address electrodes Ab in the lower divided screen ES2 are driven by a second address driver 89B. In other words, the divided screens ES1 & ES2 are constituted so that the divided screens can be driven independently from each other. The plan view shape of the address electrodes is identical to those of fifth and sixth PDPs 5 and 6, where the width of the address electrode varies cyclically.

[0058] Address electrodes being arranged by one for two rows reduces approximately by half the prior reactive power consumption caused from the static capacitance between the address electrodes; however, the time required in addressing a single line is doubled. However, the concurrent addressing of both the divided screens ES1 & ES2 allows an achievement of the whole screen addressing in a time equal to that of the prior method.

[0059] Fig. 13 schematically illustrates an electrode structure of an eighth PDP 8 as an eighth preferred embodiment of the present invention.

[0060] The entire screen of the eighth PDP 8 is divided into four in the row direction. In each divided screen ES11, ES12, ES21 & ES22 are respectively arranged address electrodes A11, A12, A21 & A22 spaced out by a pitch p: 260μm, i.e. twice the cell pitch h:130μm, in the line direction so as to be involved in adjacent rows. In the uppermost divided screen, i.e. a first screen, ES11, there is further provided between adjacent address electrodes a lead conductor At which is an extension of address electrode of the second divided screen ES12 so as to feed the address electrode thereof. In a similar way, in the lowest divided screen, i.e. a fourth screen, ES12, there is further provided between adjacent address electrodes a lead conductor At which is an extension of the address electrode of the third divided screen ES22. Accordingly, in the first and fourth screens ES11 & ES21 the arrangement pitch of address electrodes including those of the two central screens, i.e. the second & third screens ES12 & ES22, becomes substantially equal to the cell pitch. Therefore, the particular screen of the present invention described above is related to the two central divided screens ES12 & ES22.

[0061] Two upper divided screens ES11 & ES12 are driven by a first address driver 90A, and two lower divided screens ES21 & ES22 are driven by a second address driver 90B. Thus, four divided screens ES11, ES12, ES21 & ES22 can be driven independently from each other. Such a parallel addressing operation reduces the addressing period required for addressing the entire screen to a half of the prior method.

[0062] Waveforms typically employed in TABLE 2 during the address period are illustrated in Fig. 15. As seen there, the first and second halves of the addressing are performed for each line requiring as many as n pulses for Xi electrodes & Xi+1 electrodes, respectively, where n indicates the quantity of Y electrodes.

[0063] Fig. 15 and TABLE 4 schematically illustrate waveforms and time sequence of a ninth preferred embodiment of the present invention. The ninth preferred embodiment is an improved alternative method to drive during the ad-

dressing period the PDPs having the Xi, Yi & Xi+1 electrode arrangements of the second to eighth preferred embodiments.

[0064] In the ninth preferred embodiment, all of the first halves of the addressing periods are processed first so that each Yi electrode and the related odd-numbered Xi electrode are sequentially activated while continuously keeping all the odd-numbered Xi electrodes ON; next, all of the second halves of the addressing periods are processed so that each Yi electrode and the related even-numbered Xi+1 electrode are sequentially activated while continuously keeping all the even-numbered Xi+1 electrodes ON. This driving method is advantageous over the driving method shown in TABLE 2 & 3 and Fig. 16, where the odd-numbered Xi electrodes and even-numbered Xi+1 electrodes are driven for each alternate first and second half of the addressing periods; accordingly, the power required in driving the X electrodes is n times of the ninth preferred embodiment.

TABLE 4 i: an odd number

	1^{st}	2^{nd} ...	i^{th} lines			Data of Address/Data Electrodes
Scan Period	Y_1	Y_2	Yi	Xi	Xi+1	A_1 ... $A_{(m/2)}$
1^{st} half of 1^{st} line	ON	--	--	ON		data of even-numb'd row
1^{st} half of 2^{nd} line	--	ON	--	ON		data of even-numb'd row
:			--			:
:				..		:
1^{st} half of n^{th} line	--	--	ON	ON	--	data of even-numb'd row
2^{nd} half of 1^{st} line	ON	--	--	--	ON	data of odd-numb'd row
2^{nd} half of 2^{nd} line	--	ON	--	--	ON	data of odd-numb'd row
:						
:						
2^{nd} half of n^{th} line			ON		ON	data of odd-numb'd row

[0065] The above description refers to surface-discharge type PDPs embodied in the reflection type, however, of course the present invention can be embodied in transmission type PDPs provided with fluorescent material layers 28R, 28G & 28B on the front substrate. In the transmission type PDPs, owing to the three kinds of sustain electrodes arranged on the back substrate no transparent electrically conductive material is necessary in forming these electrodes.

[0066] It is apparent that the present invention can also be embodied in an opposing discharge type PDP, an LCD, i.e. a liquid crystal display device and a PALC, i.e. a plasma-addressed liquid crystal device.

[0067] The many features and advantages of the invention are apparent from the description.

[0068] It will be apparent to those skilled in the art that various modifications can be made to the display panel of the present invention. Thus, the present invention covers such modifications as well as variations thereof, within the scope of the appended claims.

Claims

1. A display panel comprising:

a plurality of scan electrodes extending along a line direction of a display matrix;
a plurality of data electrodes extending along a row direction of said display matrix, a single one of said data electrodes being allocated to and bridging adjacent two of said rows, within a specific display area formed of a plurality of said lines sequential in an arrangement order thereof, said display area being an entire or a part. of a screen to be displayed, and
wherein a plurality of said scan electrodes are allocated to a single one of said lines so that said scan electrode can engage either one of said two rows corresponding to said each data electrode.

2. A display panel as recited in claim 1, wherein each line comprises a first discrete electrode and a second discrete electrode, as said scan electrode, to each of which a voltage can be applied independently of other lines.

3. A display panel as recited in claim 1, wherein each line in said specific display area comprises:

a discrete electrode, as said scan electrode, to which a voltage can be applied independently of other scan electrodes; and
a first common electrode and a second common electrode as the scan electrode arranged so as to put said discrete electrode therebetween, said first common electrode being electrically common, and said second common electrode being electrically common.

4. A display panel as recited in claim 1, 2 or 3, wherein each of said data electrodes in said specific display area is formed in the shape of a straight stripe (or strip) extending from one end of said row in said specific display area to another end thereof.

5. A display panel as recited in claim 1, 2, or 3, wherein each of said data electrodes in said specific display area is formed in the shape of a regularly zigzagging stripe extending from an end of said row in said specific display area to another end thereof.

6. A display panel as recited in claim 1, 2, or 3, wherein each of said data electrodes in said specific display area is formed of a stripe whose width varies in a regular way such that said stripe is formed of a base extending straight from one end of said row in said specific display area to another end thereof and portions expanded alternately from one side and from another side of said base toward said line direction.

7. A display panel as recited in any preceding claim, wherein said scan electrode comprises a portion expanded alternately from one side and from another side of said scan electrode toward said row direction such that said expanded portion confronts an expanding portion of an adjacent scan electrode, a gap therebetween forming a surface discharge gap.

8. A display panel as recited in any preceding claim, wherein two of said scan electrodes are allocated to said single line.

9. A display panel as recited in any of claims 1 to 7, wherein three of said scan electrodes are allocated to said single line.

10. A display panel as recited in claim 5 or 6, further comprising a separator wall for dividing a discharge space corresponding to each row at least in said specific display area into each line.

11. A display panel as recited in claim 5 or 6, further comprising separator walls which zigzag and extend along said row direction such that a width in said line direction of said discharge space which corresponds to each row is narrowed for every two lines at least in said specific display area.

12. A display panel as recited in any preceding claim, wherein said screen is formed of two divided display areas adjacent in said row direction, and in each of said divided display areas data to be displayed can be set independent of each other, each divided display area being said specific display area.

13. A display panel as recited in any of claims 1 to 11, wherein said display area is formed of four divided display areas side by side along said row direction, in each of said divided display areas data to be displayed can be set independent of each other, and wherein an electrical lead of a data electrode of two inner divided display areas is arranged between two adjacent data electrodes of adjacent outer divided display area.

14. A driving method of driving a display matrix of a display panel as recited in claim 3, said method comprising:
a step for setting data to be displayed on a line in said specific display area, wherein said step is divided into a first half period and a second half period, wherein during said first half period a first one of said two rows associated with said each data electrode performs said setting of said data, and during said second half period a second one of said two rows associated with said data electrode performs said setting of said data.

15. A driving method as recited in claim 14, wherein said discrete electrode and said first common electrode are utilized in setting said data during said first half period, and said discrete electrode and said second common electrode are utilized in setting data during said second half period.

16. A display panel as recited in claim 15, wherein said setting of said data is performed according to the steps of:

setting said data of said first half period sequentially for more than two lines; and
setting said data of said second half period for said more than two lines.

17. A method to drive a display panel comprising:

a plurality of scan electrodes extending along a line direction of a display matrix formed of lines and rows;
a plurality of data electrodes extending along a row direction of said display matrix, a single one of said data electrodes being allocated to and bridging adjacent two of said rows, within a specific display area formed of a plurality of said lines sequential in an arrangement order thereof, said display area being an entire or a part of a screen to be displayed,
wherein three of said scan electrodes are related to a single one of said lines so that said three scan electrodes can engage either one of said two adjacent rows corresponding to said each data electrode, and
wherein said three scan electrodes comprise a discrete electrode to which a voltage can be applied independently of other lines, and a first common electrode and a second common electrode so as to place said discrete electrode therebetween, said first common electrode being electrically common to first common electrodes of other lines, and said second common electrode being electrically common to second common electrodes of said other lines,
said method comprising the steps of:
dividing a period for setting data to be displayed on a plurality of lines into a first half period and a second half period;
during said first half period, said each data electrode performing said setting of data of a first one of said two rows associated with said data electrode onto a first display cell formed between said first common electrode and said data electrode by the use of said first common electrode and said discrete electrode; and
during said second half period, said each data electrode performing said setting of data of a second one of said two rows associated with said data electrode onto a second display cell formed between said second common electrode and said data electrode by the use of said second common electrode and said discrete electrode.

Fig. 1

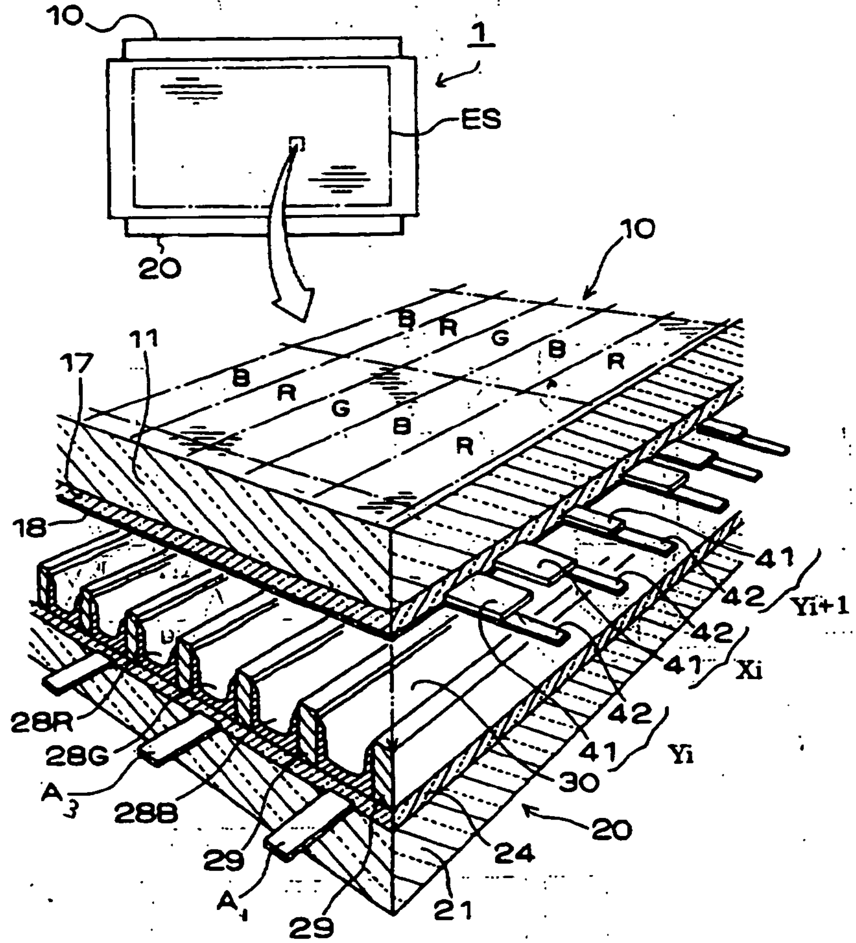

10
1
ES
20
10
B
R
G
B
R
B
R
G
B
R
17
11
18
41
42
Yi+1
42
41
Xi
42
41
Yi
30
20
24
21
28R
28G
A3
28B
29
A1
29

Fig. 2

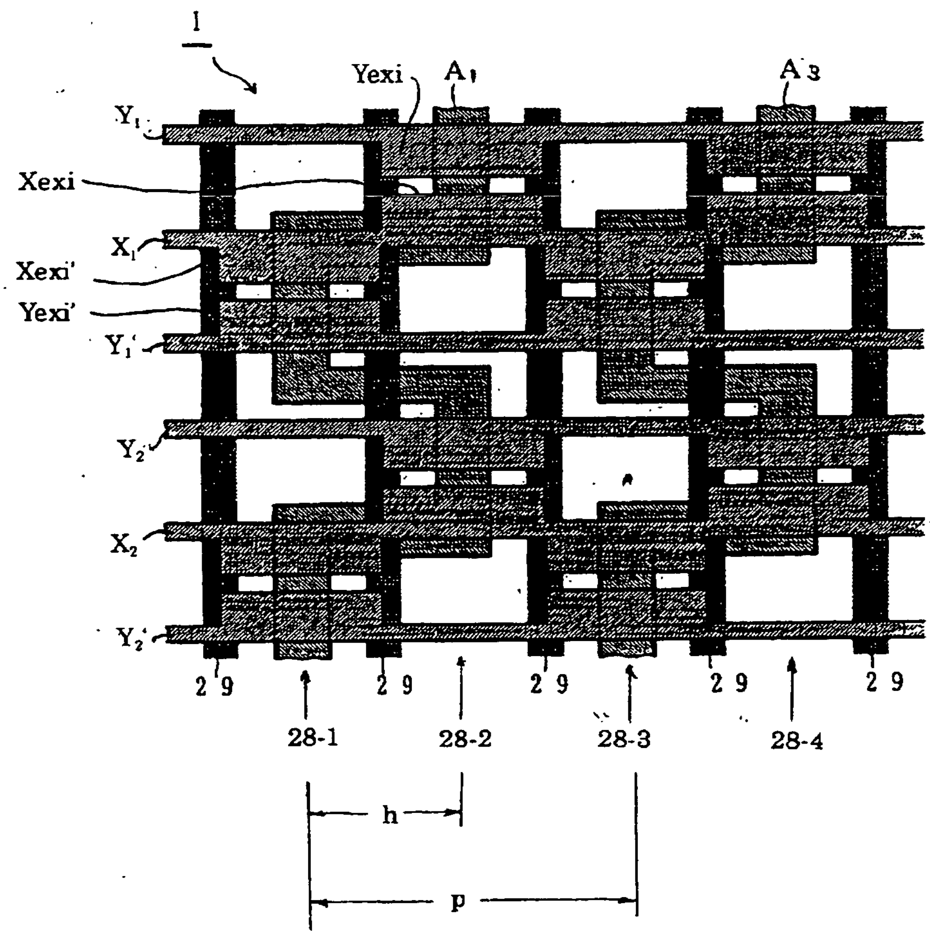

1
Yexi
A1
A3
Y1
Xexi
X1
Xexi'
Yexi'
Y1'
Y2
X2
Y2'
29
29
29
29
29
28-1
28-2
28-3
28-4
h
p

Fig. 3.A

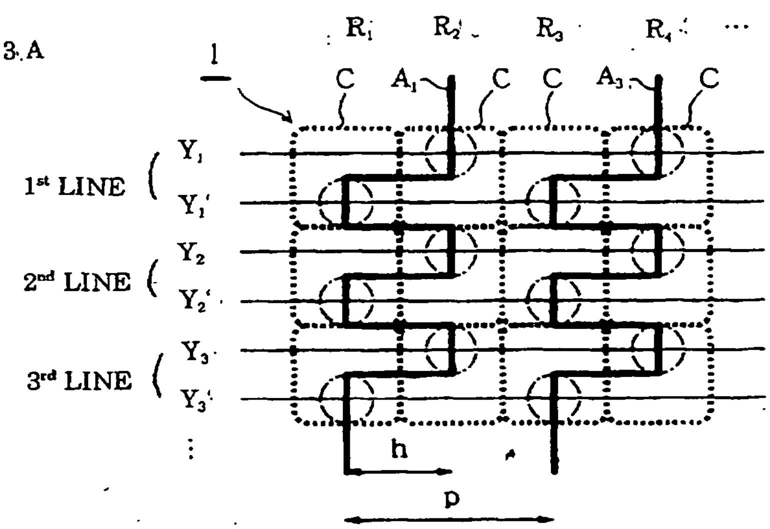

R1
R2
R3
R4
...
1
C
A1
C
C
A3
C
Y1
1st LINE
Y1'
Y2
2nd LINE
Y2'
Y3
3rd LINE
Y3'
h
p

Fig. 3 B

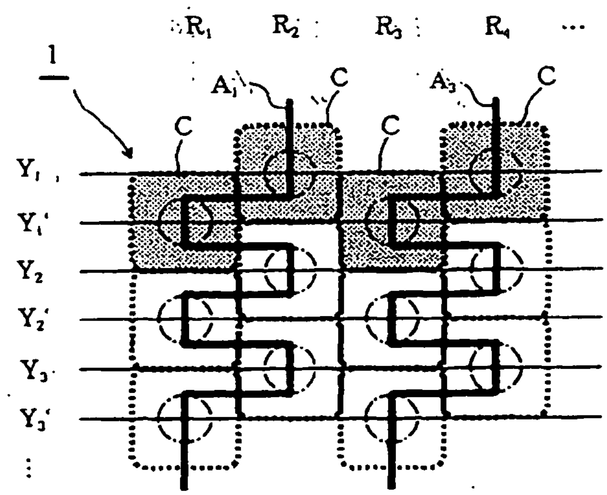

R1
R2
R3
R4
...
1
A1
C
A3
C
C
C
Y1
Y1'
Y2
Y2'
Y3
Y3'

Fig. 4

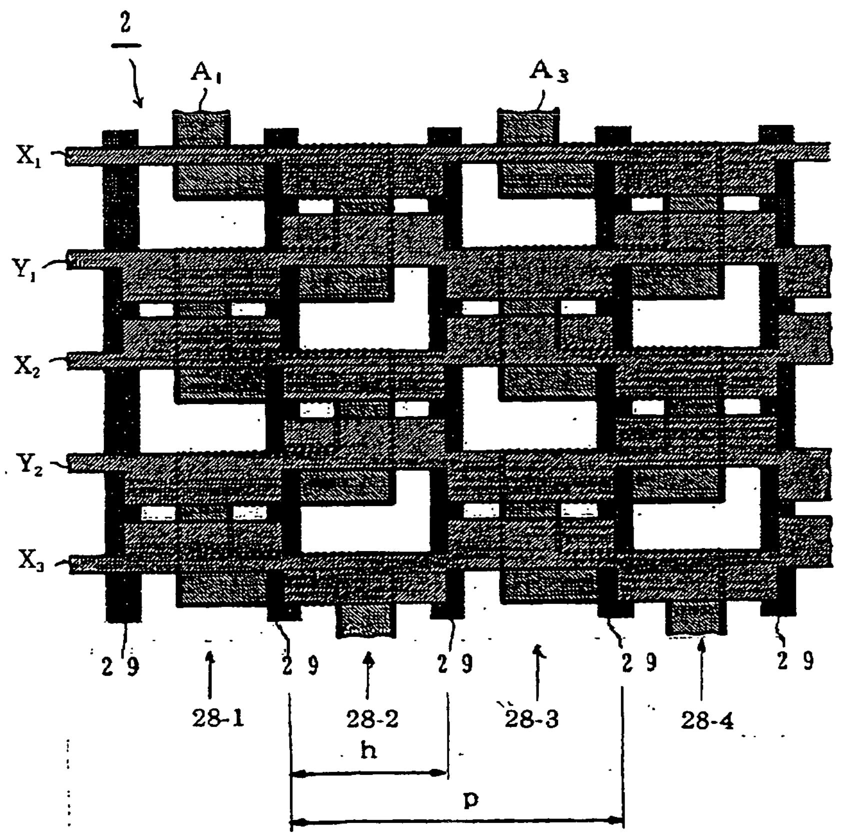


Fig. 5

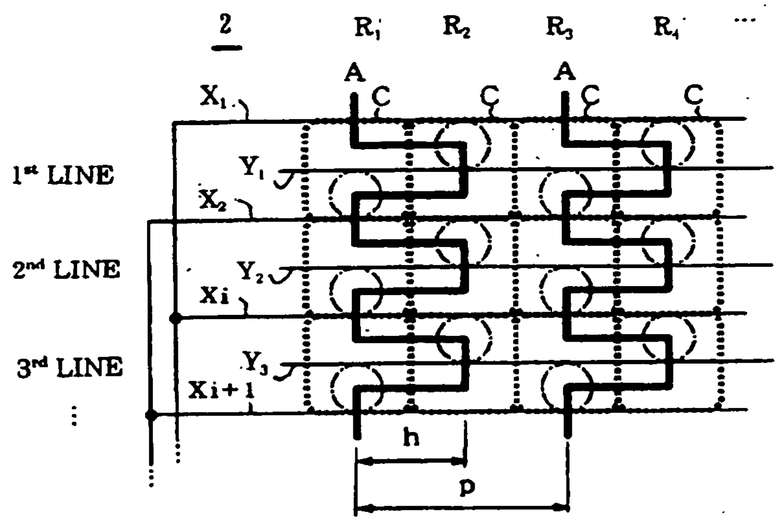

2
R1
R2
R3
R4
...
A
C
C
A
C
C
X1
1st LINE
Y1
X2
2nd LINE
Y2
Xi
3rd LINE
Y3
Xi+1
h
p

Fig. 6

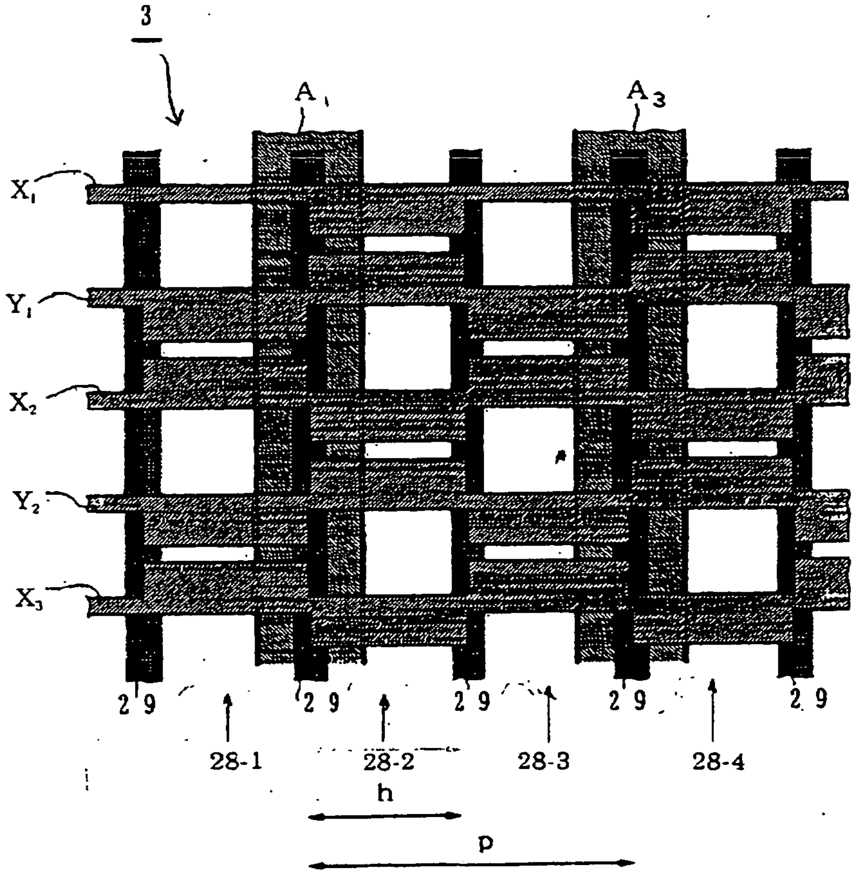


Fig.7

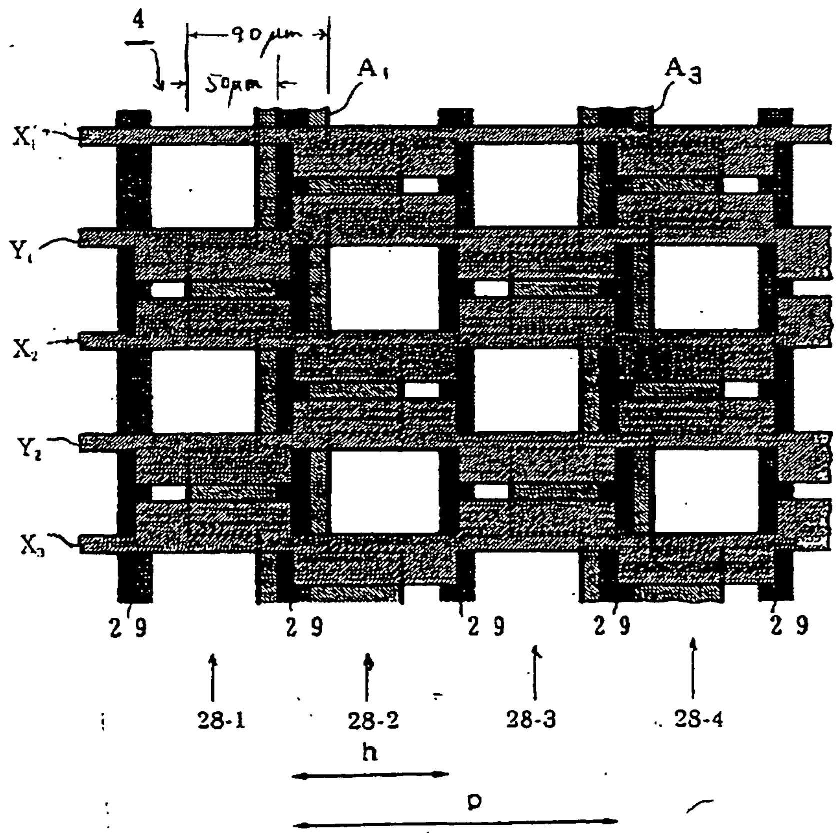
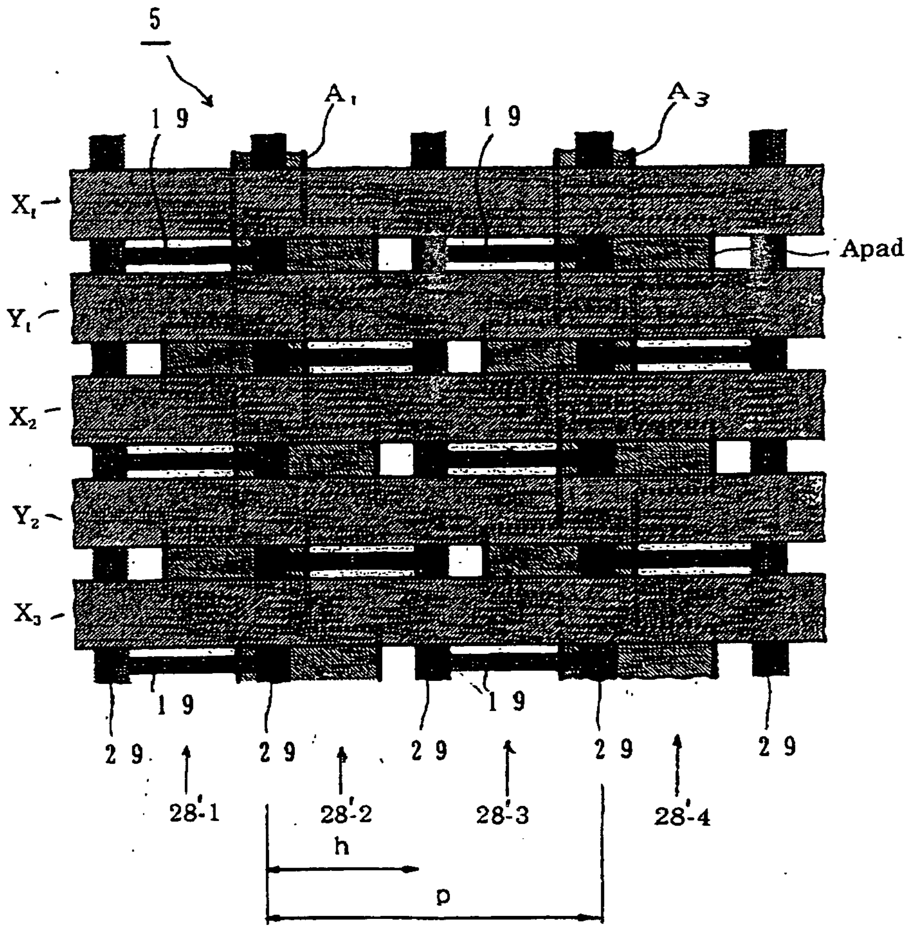


Fig.8



5
19
A1
19
A3
X1
Apad
Y1
X2
Y2
X3
19
19
29
29
29
29
29
28'-1
28'-2
28'-3
28'-4
h
p

Fig. 9 A

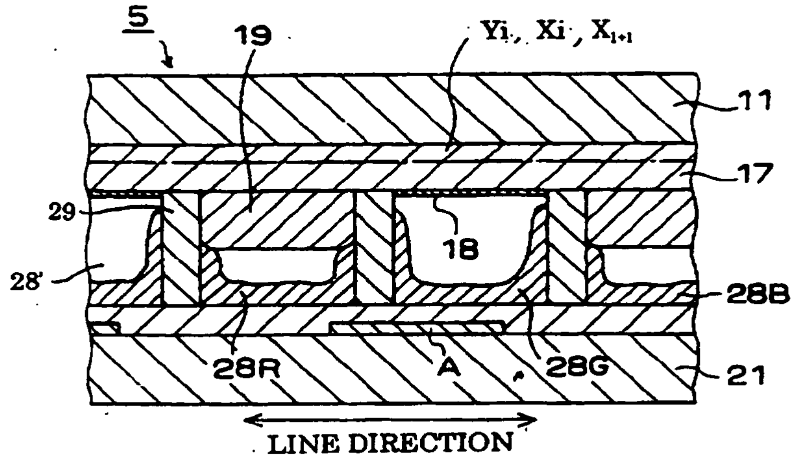

5
19
Yi, Xi, X_{i+1}
11
17
29
18
28'
28B
28R
A
28G
21
LINE DIRECTION

Fig. 9 B

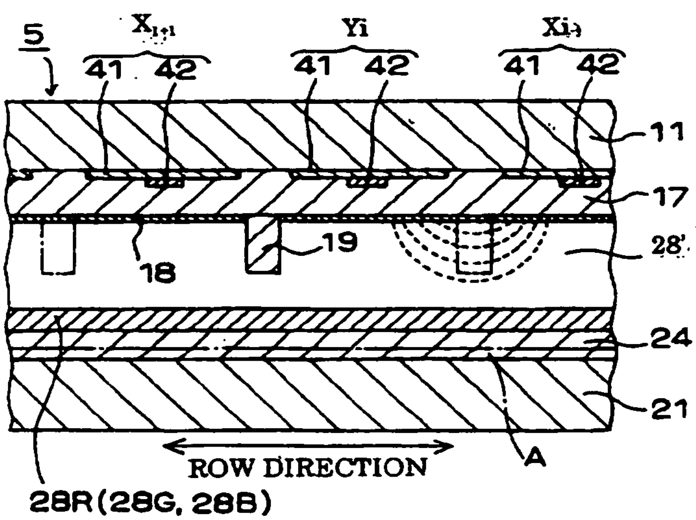

5
X_{i+1}
Yi
Xi
41 42
41 42
41 42
11
17
18
19
28'
24
21
A
ROW DIRECTION
28R(28G, 28B)

Fig. 10

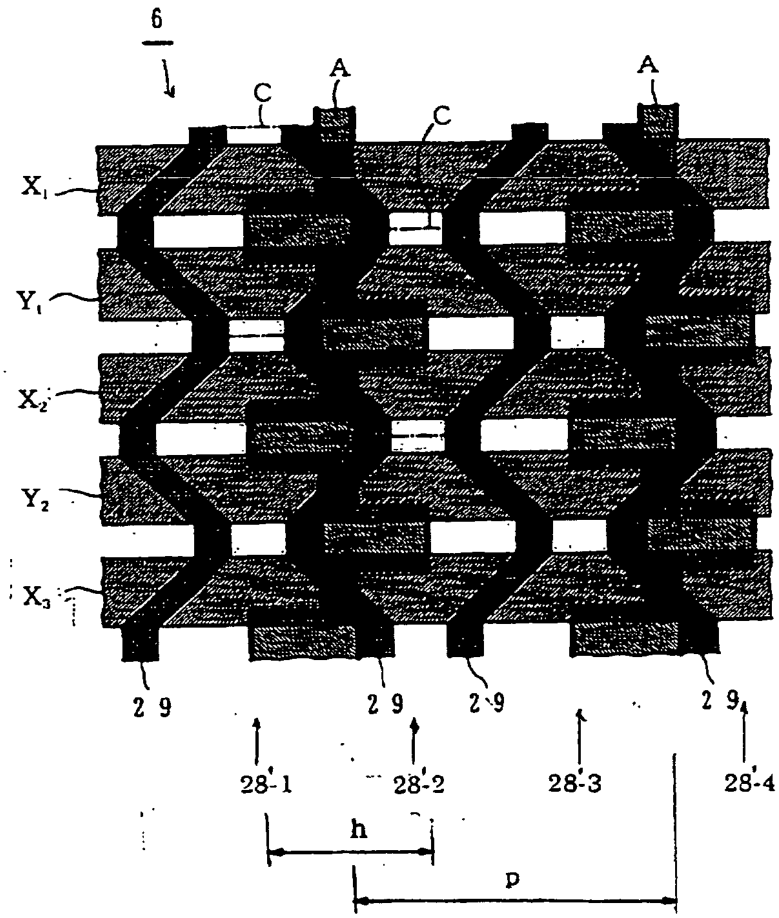


Fig. 11

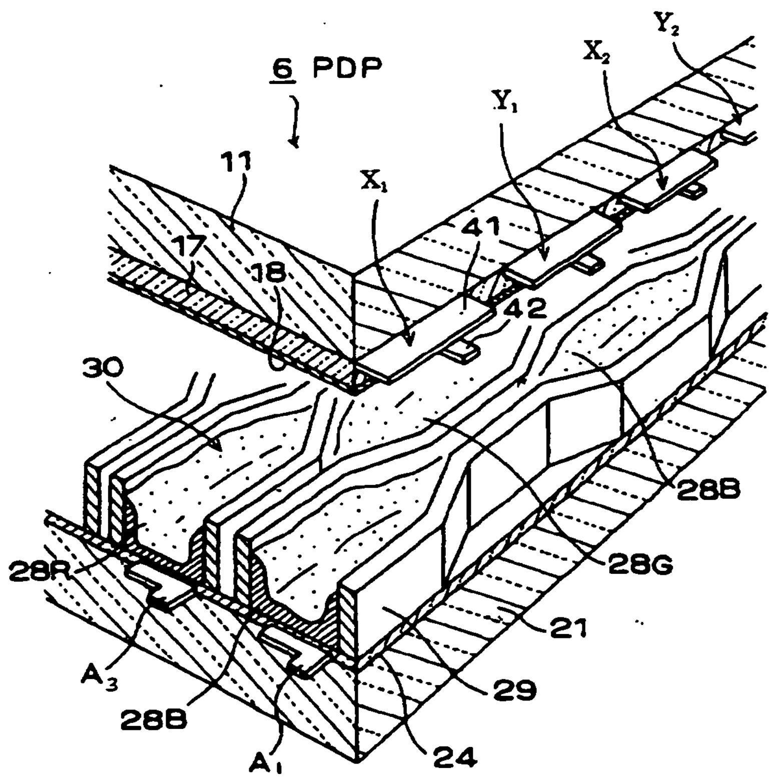


Fig. 12

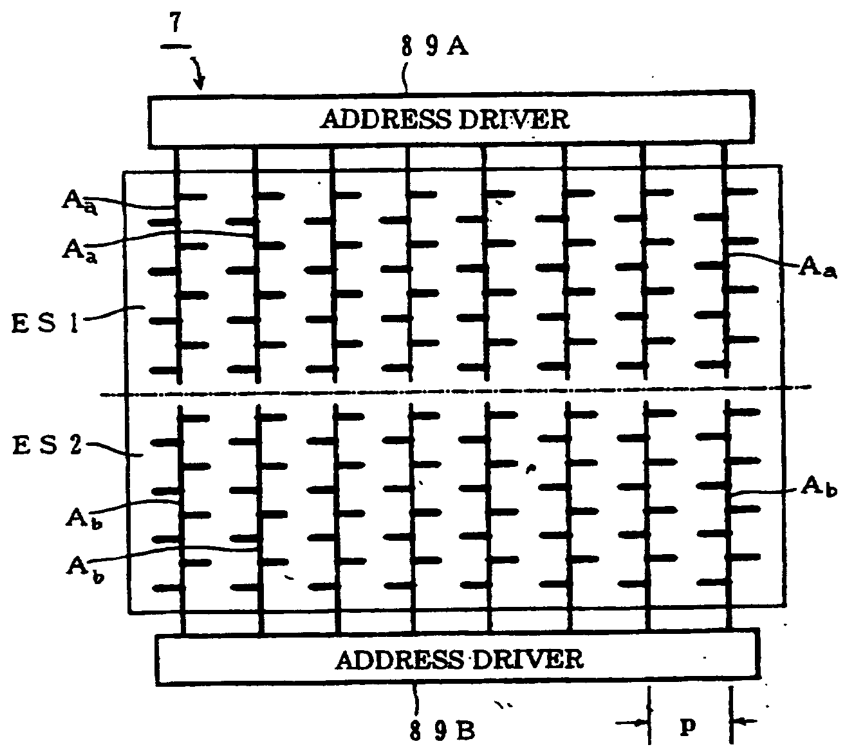


Fig. 13

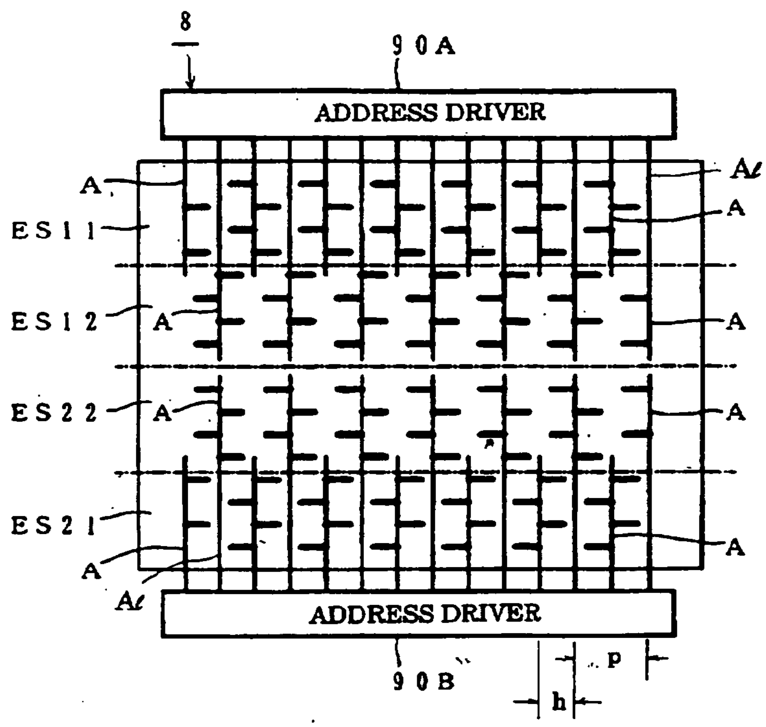


Fig. 14

PRIOR ART

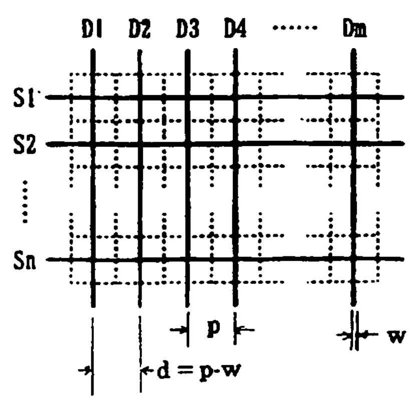


Fig. 15

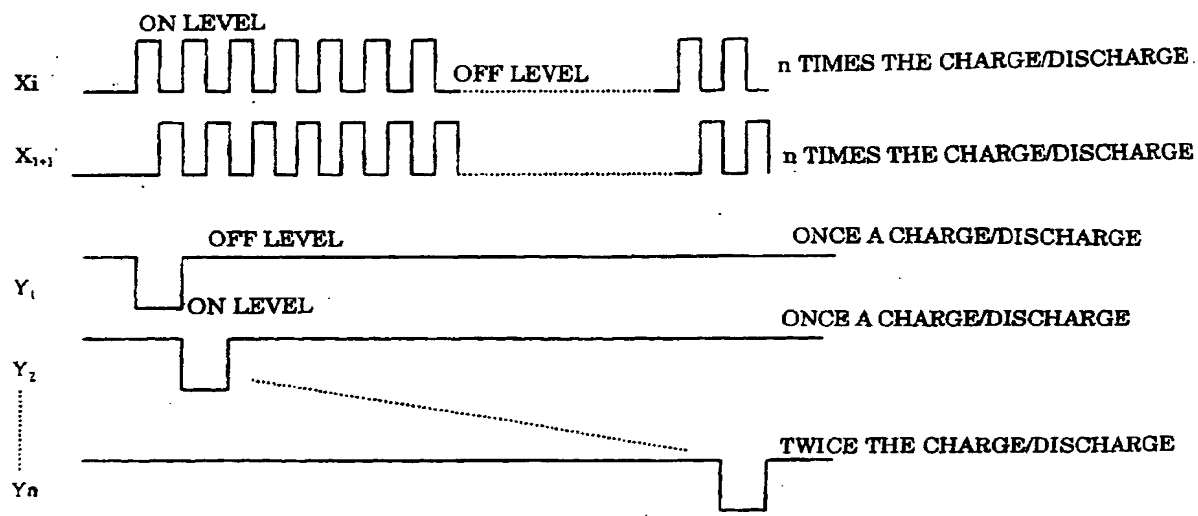
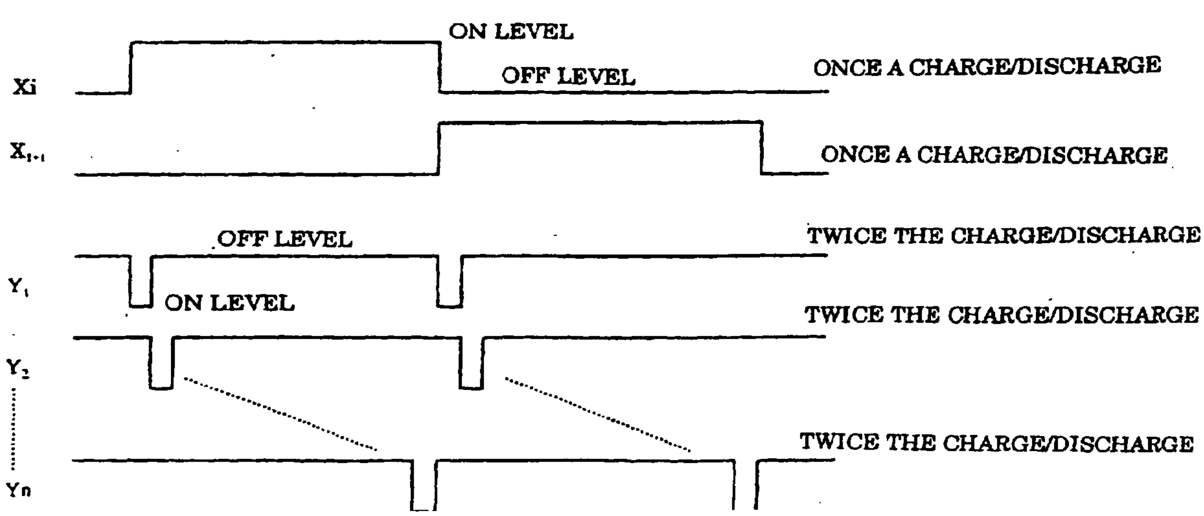

ON LEVEL
Xi
OFF LEVEL
n TIMES THE CHARGE/DISCHARGE
X_{i+1}
n TIMES THE CHARGE/DISCHARGE
OFF LEVEL
ONCE A CHARGE/DISCHARGE
Y_1
ON LEVEL
ONCE A CHARGE/DISCHARGE
Y_2
TWICE THE CHARGE/DISCHARGE
Yn

Fig. 16


ON LEVEL
Xi
OFF LEVEL
ONCE A CHARGE/DISCHARGE
X_{i+1}
ONCE A CHARGE/DISCHARGE
OFF LEVEL
TWICE THE CHARGE/DISCHARGE
Y_1
ON LEVEL
TWICE THE CHARGE/DISCHARGE
Y_2
TWICE THE CHARGE/DISCHARGE
Yn

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 99 30 0953

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
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X A	KEHOE J L: "COMPETITIVELY PRICED AC PLASMA DISPLAYS" WESCON TECHNICAL PAPERS, vol. 33, 1 November 1989, pages 757-759, XP000116093 * page 757, right-hand column, line 34 - line 45; figure 1 *	1-4 5-17	
Y A	GB 2 061 612 A (NV PHILIPS GLOEILAMPENFABRIEKEN) 13 May 1981 * abstract * * page 1, line 107 - page 2, line 13 * * page 2, line 79 - line 110 * * page 4, line 20 - line 73; figures 1-5 *	6 7	TECHNICAL FIELDS SEARCHED (Int.Cl.6) G09G H01J
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	11 June 1999	O'Reilly, D

CATEGORY OF CITED DOCUMENTS

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EP 99 30 0953

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The members are as contained in the European Patent Office EDP file on
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11-06-1999

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